

Embodying Social Rank

How body fat varies with social status,
gender and ethnicity in New Zealand

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MANATŪ HAUORA

Foreword

Obesity has long been recognised by the Ministry of Health as a major public health issue. Improving nutrition and reducing obesity are priority objectives in the New Zealand Health Strategy, launched by the Minister of Health in December 2000.

The burden of obesity and overweight is growing, as mean body mass index (BMI) and the prevalence of obesity continue to increase in New Zealand – the latter doubling over the past quarter century among both males and females. Until now we have lacked a description of disparities between socioeconomic groups in the full BMI distribution, and how such socioeconomic gradients differ between genders and ethnic groups. Such a description is the purpose of the present study. Using measured BMI and waist circumference (WC) from the 2002/03 New Zealand Health Survey, we have applied graphical techniques to visualise differences in the socioeconomic gradients in BMI and WC distributions among adults, stratified by gender and Māori – non-Māori ethnicity. The results not only provide a richer and more comprehensive picture of socioeconomic disparities in the obesity epidemic than were previously available, but also reveal potentially important differences in these disparities between males and females, and between Māori and non-Māori.

The information provided in this report will be useful in further developing and evaluating the Ministry's Healthy Eating – Healthy Action strategy, launched by the Minister of Health in March 2003, and the strategy's Implementation Plan, launched by the Minister in June 2004. In fact, this report may well represent the most thorough and comprehensive description of ethnic and gender variations in socioeconomic gradients within a national obesity epidemic yet produced for any country. In particular, its focus on the full BMI and WC distributions and its use of innovative graphical techniques to visualise and quantify disparities in these distributions provide a solid evidence base for policy and planning. While the report is national in scope, District Health Boards and primary health organisations (PHOs) may find this information of value in framing their own responses to the epidemic. Indeed, as the setting in which population health meets personal health care, PHOs in particular have a critical role to play in bringing the epidemic under control and minimising its harm.

We invite readers to comment on the content, relevance and direction of this report. Please direct any comments to Public Health Intelligence, Ministry of Health, PO Box 5013, Wellington.



Don Matheson
Deputy Director-General, Public Health Directorate

Acknowledgements and Disclaimer

The analysis was done and the report written by Martin Tobias, Sue Paul and Li-Chia Yeh (Public Health Intelligence).

The authors are grateful to the approximately 13,000 New Zealanders who freely gave of their time to participate in the 2002/03 New Zealand Health Survey. Useful feedback from peer reviewers within and outside the Ministry of Health is also gratefully acknowledged.

The views expressed in this report are the authors' own and do not necessarily reflect the policy advice of the Ministry of Health.

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Executive Summary

Objective

The aim of this analysis was to quantify ethnic and gender variation in the socioeconomic gradient in body fat in New Zealand, using different measures of socioeconomic position and body fat. Understanding such variation, and trends in this variation over time, may be relevant in formulating and evaluating policies and interventions under the Ministry's Healthy Eating – Healthy Action initiative (Ministry of Health 2004b).

Method

The 2002/03 New Zealand Health Survey was used to derive kernel-smoothed estimates of the population's body mass index (BMI) and waist circumference (WC) distributions. The percentiles of these distributions were then used to create Tukey mean–difference plots to graphically analyse the difference in body fat distributions between socioeconomic groups, stratified by Māori and non-Māori ethnicity and by gender. Age confounding was adjusted for by direct standardisation. Three different measures of socioeconomic position (SEP) were used: educational qualifications (individual-level measure), household income (household-level measure) and New Zealand Deprivation Index (neighbourhood-level measure).

Results

Overall, in 2002/03 both BMI and WC distributions were strongly associated with SEP, whether measured at the individual, household or neighbourhood level. Furthermore, the association was similar in direction and magnitude for both markers of body fat, with the inverse gradient increasing at higher BMI or WC percentiles. However, the association was modified by both gender and ethnicity. Non-Māori females showed a strong inverse socioeconomic gradient for BMI and WC, non-Māori males a much shallower inverse gradient, Māori females little if any relationship, and Māori males a moderately strong *direct* gradient (ie, among Māori males, higher SEP was associated with larger BMI or WC).

Discussion

The different patterning of socioeconomic gradients in body fat by gender and ethnicity may reflect differential timing of the obesity epidemic in these population groups, cultural or behavioural differences, and/or differential life-course effects. If so, the ethnic differences in the gradients may be expected to change over time. These patterns, and any future trends in these patterns, need to be taken into account when designing or evaluating policies under the Ministry's Healthy Eating – Healthy Action initiative. This is because different ethnic groups and genders may be expected to respond differently to such interventions, reflecting differences in their socioeconomic gradients in body fat.

Introduction

Dramatic increases in the prevalence of obesity have been experienced in recent years in both developing and developed countries, including New Zealand (Ministry of Health 2004c). The social patterning of this increase in body fat mass has typically been inequitable, with disadvantaged and marginalised groups showing larger shifts than their more advantaged counterparts (Zhang and Wang 2004; Ball and Crawford 2004). Generally, the increase in body fat has been more marked for women than for men, for middle-aged than for older or younger age groups, and for indigenous or ethnic minority populations than for those from the dominant culture (Aranceta et al 2001; Dryson et al 1992; Ministry of Health 2004c).

Body mass index (BMI) (weight in kilograms divided by height in metres squared) is widely accepted as an appropriate population-level indicator of excess body fat (WHO 2000b). Waist circumference (WC) is an alternative anthropometric measure that also indicates whether excess body fat is centrally or peripherally located (Janssen et al 2004). Most studies in New Zealand and internationally have examined only obesity prevalence, rather than the full population BMI or WC distribution, yet the definition of 'obesity' is based on an arbitrary threshold of BMI. Health risk is in fact continuously related to adipose tissue mass (Asia Pacific Cohort Studies Collaboration 2004). Hence, associations of socioeconomic position (SEP) with the full BMI (or WC) distributions may imply different policy actions to those suggested by a more limited analysis restricted to the prevalence of obesity alone.

Different measures of SEP may be selected for the exposure variable, capturing socioeconomic resources at three different levels: individual, household and neighbourhood. Again, this would represent a wider gaze than most previous studies, which have typically been narrowly focused on a single dimension of SEP, and provide only a limited perspective on the embodiment of social rank (Krieger 2004).

Ethnic and gender differences in the socioeconomic gradient of obesity in New Zealand have not previously been investigated in a nationally representative sample of adults, although some studies have been done in local community or workforce samples (Swinburn et al 1999; Schaaf et al 2000; Metcalf et al in press; McDonald-Sundborn et al 2005). The purpose of this report is to analyse this socioeconomic gradient in detail for a nationally representative population sample, by examining the full distributions of body mass index and waist circumference according to three different measures of socioeconomic position, stratified by gender and Māori–non-Māori ethnicity.

Differences in these gradients, and trends in such differences over time, may be relevant to the design, implementation and evaluation of policies and interventions under the Ministry of Health's Healthy Eating – Healthy Action initiative (Ministry of Health 2004b).

Methods

The 2002/03 New Zealand Health Survey (NZHS)

The 2002/03 NZHS was a household survey with a stratified multi-stage cluster design based on an area sampling frame (Ministry of Health 2004a). The target population was the usually resident, non-institutionalised civilian adult population (aged 15 years and over) living in permanent private dwellings. One (randomly selected) adult was interviewed (face to face, in English) from each chosen dwelling. A total of 12,929 people responded to the survey, including a Māori, Pacific and Asian oversample, giving an overall response rate of approximately 72%.

Respondents aged 75 or over (approximately 6% of respondents) were excluded from this study, as BMI is unstable in older age groups. Respondents missing either BMI or WC measurements (approximately 10% of respondents) were likewise excluded. This left 10,813 participants for inclusion in the study. Respondents aged 15–17 years were not excluded, even though they may not have reached their adult BMI or WC, because of the small number in this age group.

Survey weights and variance estimation

Survey weights were used to take the complex and clustered design of the NZHS 2002/03 into account, and to make all estimates nationally representative (Ministry of Health 2004b). Replicate weights were used for variance estimation (Kott 2001).

Variable definitions

Height measurements were made without footwear using a portable stadiometer. Weight measurements were made using a SECA Model 770 scale. Waist measurements were made at the natural narrowing midway between the last rib and the crest of the ilium. The measurement was taken at the end of a normal expiration. Two height, weight and waist measurements were made to the nearest 0.1 cm, 0.1 kg and 0.1 cm respectively. If these measurements differed by more than 0.5 cm, 0.5 kg or 1.0 cm respectively a third measurement was taken. The final measurement was the mean of the two closest measures.

Ethnicity was categorised as Māori or non-Māori, as self-identified in the survey. Respondents claiming multiple ethnic identities were coded as Māori if this was one of the identities reported, or as non-Māori otherwise. Despite oversampling, there was insufficient power to stratify by Pacific and Asian ethnicity. These ethnic groups were included in the non-Māori category.

The highest educational qualification obtained by the survey respondent was used to establish educational status. Education was modelled as a categorical variable with three levels:

- high: tertiary qualification (either university or polytechnic degree)
- intermediate: high school qualification, trade certificate or (non-postgraduate) diploma
- low: no educational qualification.

Household income was discretised into the following categories (approximately tertiles):

- low: annual gross household income from all sources of \$30,000 or less
- medium: \$30,001–\$70,000
- high: more than \$70,000.

Household incomes were not equivalised for household size or composition.

Neighbourhood deprivation was measured by means of a census-based small area index of deprivation, the NZDep2001 (Salmond and Crampton 2002). Neighbourhood deprivation categories were created by asymmetrically collapsing quintiles of NZDep2001 scores into three categories (necessary to enable analysis of the Māori data):

- least disadvantaged: quintiles 1 and 2
- intermediate: quintiles 3 and 4
- most disadvantaged: quintile 5.

Category definitions for all socioeconomic variables are summarised in Table 1.

Table 1: Category definitions for socioeconomic variables

Variable	Category	Definition
Education	Educ 1	University or polytechnic degree
	Educ 2	High school qualification, trade certificate, or non-postgraduate diploma
	Educ 3	No qualifications
Household income	Inc 1 (high)	Annual gross (all sources) \$70,001 or more
	Inc 2 (medium)	\$30,001–\$70,000
	Inc 3 (low)	\$30,000 or less
Neighbourhood deprivation	Dep Cat 1	Quintiles 1 and 2 (least deprived)
	Dep Cat 2	Quintiles 3 and 4
	Dep Cat 3	Quintile 5 (most deprived)

Age standardisation

All results have been age standardised to control for age as a confounder. This was done by the direct method using the WHO world population as the reference (WHO 2000a).

Imputing household income

Approximately 3000 respondents did not supply their household income. This is not uncommon, as respondents are often unwilling to disclose this information or simply do not know what the total household income is. Missing values were imputed using a nearest neighbour approach with ethnicity, age, gender, education and NZDep2001 quintile as explanatory variables (Dobson 1990).

Modelling

Age-standardised BMI and WC data were smoothed using a sample-weighted Gaussian kernel density estimator (Buskirk 1998). The percentiles of these distributions were then used to create Tukey mean–difference (M–D) plots (Cleveland 1993) (see below) to describe the distributional differences between socioeconomic groups in 2002/03, stratified by gender and ethnicity.

For each marker of SEP, the distribution (BMI or WC) of the least deprived group was used as the benchmark for the Tukey M–D plots. For example, for income, medium- or low-income distributions are compared to the corresponding high-income distribution.

Ninety-five percent confidence intervals were estimated for the M–D plots using replicate weights to allow for the complex and clustered design of the survey. Differences are statistically significant if the error bar does not include $y = 0$ (shown on the plots).

Gradients

Socioeconomic gradients were classified as *inverse* if higher SEP is associated with *lower* BMI or WC, and as *direct* if higher SEP is associated with *higher* BMI or WC.

Tukey mean–difference (M–D) plots

M–D plots are graphical tools used to compare two distributions. The distributions of interest are compared by plotting the difference between the two distributions at each percentile against the mean of the two percentiles. This technique enables visualisation of both the magnitude of the distributional differences and also their location.

For example, a uniform difference across all percentiles of the two distributions indicates that the socioeconomic inequality in BMI or WC is stable across all BMI or WC levels. A pattern of increasing differences, on the other hand, indicates that the social inequality increases with increasing BMI or WC, with the largest socioeconomic inequalities being found among the morbidly obese.

A more detailed outline of M–D plots and other statistical methods to compare two distributions is provided in the appendix to this report.

Results

Descriptive

The medians and other selected percentiles of the age-standardised (within the 0–74 years age range) BMI and WC distributions by socioeconomic category, stratified by gender and ethnicity, are shown in Tables 2a and b.

Table 2a: Median and selected percentiles of BMI, by socioeconomic category, gender and ethnicity, New Zealand, 2002/03

			N	10th percentile	25th percentile	50th percentile (median)	75th percentile	90th percentile
Māori	Male	Educ 1	82	24.0	26.6	30.4	37.4	45.6
		Educ 2	674	23.2	25.1	29.0	33.1	38.5
		Educ 3	606	21.6	23.7	27.8	31.1	37.6
		Inc 1	203	23.5	26.0	29.9	34.3	43.7
		Inc 2	473	22.8	24.7	28.2	33.2	37.7
		Inc 3	658	21.8	23.7	27.9	31.2	37.4
		Dep 1	81	22.3	24.4	29.3	33.9	38.5
		Dep 2	344	22.0	24.5	28.3	33.0	39.3
		Dep 3	823	22.8	24.6	28.5	32.6	37.8
	Female	Educ 1	299	21.5	23.7	28.8	32.1	37.4
		Educ 2	1085	20.6	23.7	27.8	32.0	35.9
		Educ 3	899	21.4	24.4	28.5	34.3	40.2
		Inc 1	227	21.3	22.7	29.0	31.9	37.4
		Inc 2	732	21.3	23.9	28.8	32.5	38.1
		Inc 3	1294	21.1	23.8	27.9	32.8	39.0
		Dep 1	119	19.4	21.8	25.6	30.3	33.1
		Dep 2	524	21.4	24.2	28.4	32.5	37.4
		Dep 3	1528	21.6	24.1	29.0	33.9	40.0
Non-Māori	Male	Educ 1	708	21.4	23.3	25.6	28.5	31.3
		Educ 2	1769	20.5	22.9	25.9	28.8	32.1
		Educ 3	588	20.6	23.0	26.4	29.8	34.4
		Inc 1	874	21.4	23.5	26.0	28.8	32.1
		Inc 2	1215	20.7	23.0	26.0	29.1	32.4
		Inc 3	941	20.2	22.6	25.3	28.7	32.2
		Dep 1	1104	20.9	23.2	25.7	28.3	31.3
		Dep 2	1133	20.6	23.0	25.9	29.0	32.4
		Dep 3	750	21.0	23.2	26.3	30.4	34.3
	Female	Educ 1	1157	20.0	21.8	24.1	27.9	32.1
		Educ 2	2086	19.8	21.9	24.3	28.6	33.4
		Educ 3	853	19.6	22.5	26.4	31.2	36.6
		Inc 1	893	20.0	21.9	24.1	27.8	32.1
		Inc 2	1537	19.9	22.2	24.9	29.1	33.6
		Inc 3	1619	19.5	21.5	24.7	29.9	35.5
		Dep 1	1460	19.8	21.8	23.9	28.0	32.5
		Dep 2	1553	19.6	22.0	24.7	28.9	33.4
		Dep 3	1015	19.9	22.5	26.3	31.4	36.9

Notes: For definitions of socioeconomic categories, see Table 1 (page 3). Rates are age standardised within the range 15–74 years.

Table 2b: Median and selected percentiles of WC, by socioeconomic category, gender and ethnicity, New Zealand 2002/03

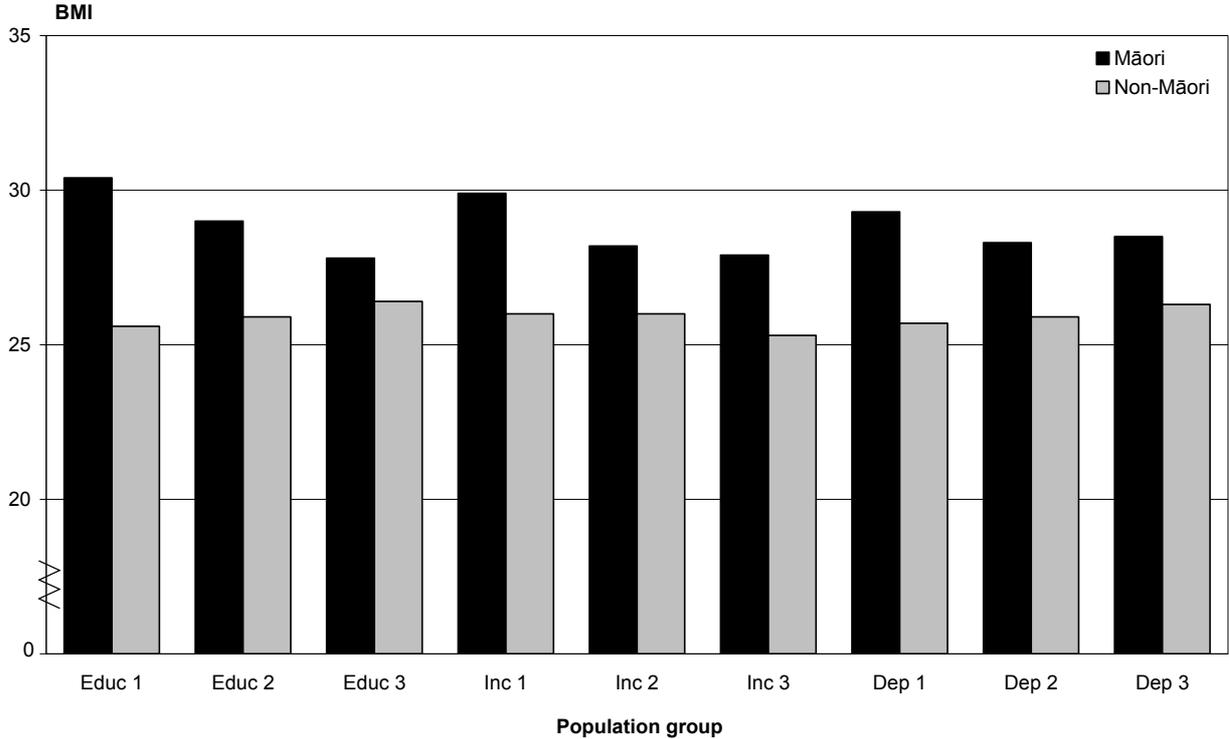
			N	10th percentile	25th percentile	50th percentile (median)	75th percentile	90th percentile
Māori	Male	Educ 1	82	86.8	93.0	102.0	112.4	132.4
		Educ 2	674	83.3	90.1	98.2	107.2	121.1
		Educ 3	606	79.5	85.2	95.8	105.0	119.4
		Inc 1	203	84.0	91.1	101.0	111.1	133.3
		Inc 2	473	80.2	88.2	97.4	106.8	118.0
		Inc 3	658	79.6	86.0	95.6	106.1	117.5
		Dep 1	81	81.0	87.0	101.2	107.0	131.7
		Dep 2	344	81.2	90.1	98.0	107.3	125.1
		Dep 3	823	79.7	88.0	96.0	105.1	118.1
	Female	Educ 1	299	70.1	80.4	89.0	98.2	107.0
		Educ 2	1085	69.0	77.0	87.5	97.7	108.5
		Educ 3	899	72.5	80.5	92.6	104.4	113.0
		Inc 1	227	69.0	78.5	90.0	97.1	103.1
		Inc 2	732	71.5	77.0	88.6	97.7	110.6
		Inc 3	1294	72.0	79.4	89.0	102.2	112.3
		Dep 1	119	66.1	72.2	83.0	91.8	100.8
		Dep 2	524	72.0	79.6	89.1	98.9	110.9
		Dep 3	1528	73.4	79.5	90.7	103.5	114.0
Non-Māori	Male	Educ 1	708	80.1	86.4	92.5	100.0	106.0
		Educ 2	1769	77.0	84.0	92.3	101.0	109.0
		Educ 3	588	78.8	84.1	94.5	105.0	114.8
		Inc 1	874	80.2	86.2	93.1	101.0	108.5
		Inc 2	1215	78.0	85.0	93.0	101.7	110.1
		Inc 3	941	75.7	83.0	91.2	101.5	109.5
		Dep 1	1104	78.0	84.5	92.0	100.0	106.7
		Dep 2	1133	78.0	84.3	92.9	101.8	109.4
		Dep 3	750	77.5	86.0	94.0	104.5	114.2
	Female	Educ 1	1157	68.0	73.5	79.1	88.4	98.5
		Educ 2	2086	68.1	73.1	79.8	90.0	100.5
		Educ 3	853	68.5	74.5	85.0	98.0	105.4
		Inc 1	893	68.0	73.0	78.9	87.0	96.5
		Inc 2	1537	69.1	73.9	81.1	91.4	100.0
		Inc 3	1619	67.9	73.5	81.9	94.4	106.0
		Dep 1	1460	68.0	72.5	78.5	88.0	99.0
		Dep 2	1553	68.1	73.3	80.0	91.0	100.5
		Dep 3	1015	69.0	76.0	85.1	97.1	109.1

Notes: For definitions of socioeconomic categories, see Table 1 (page 3). Rates are age standardised within the range 15–74 years.

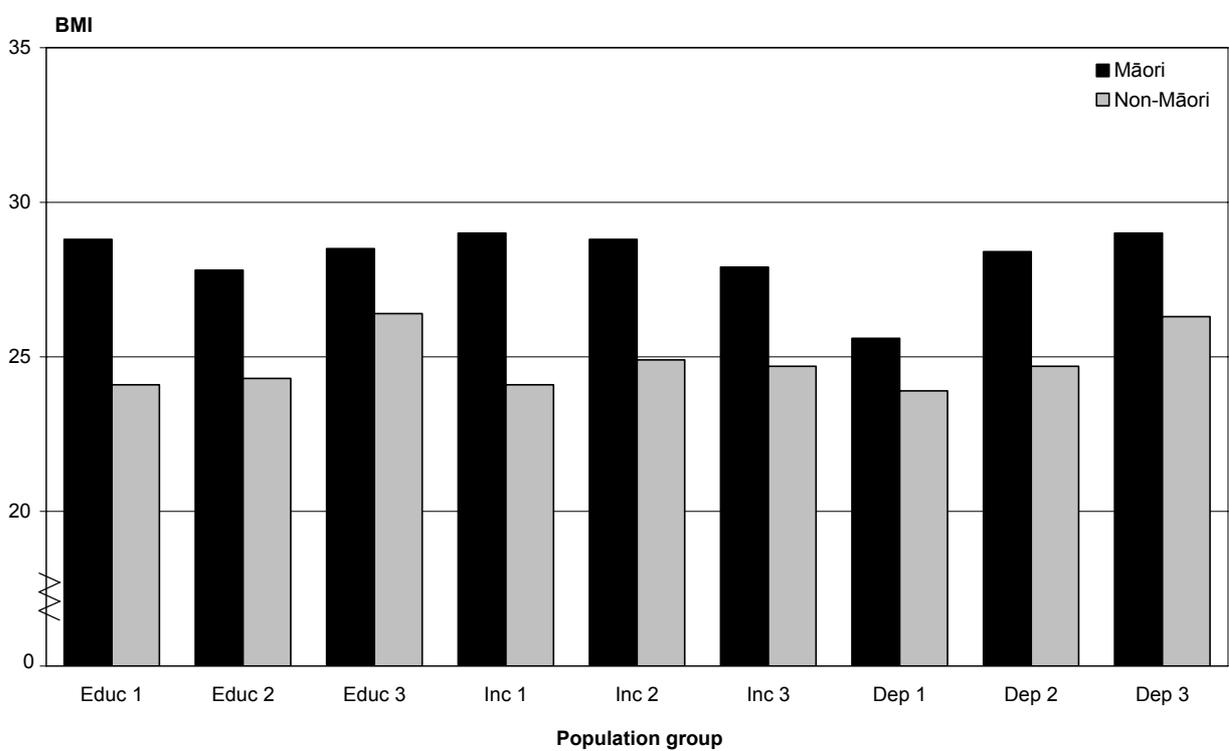
The medians of the BMI and WC distributions (50th percentiles, as reported in Table 2 above) are plotted in Figures 1a and b to illustrate graphically the variation by socioeconomic category within ethnic and gender strata.

Figure 1a: Median of BMI distributions by socioeconomic category, gender and ethnicity, New Zealand 2002/03

Males



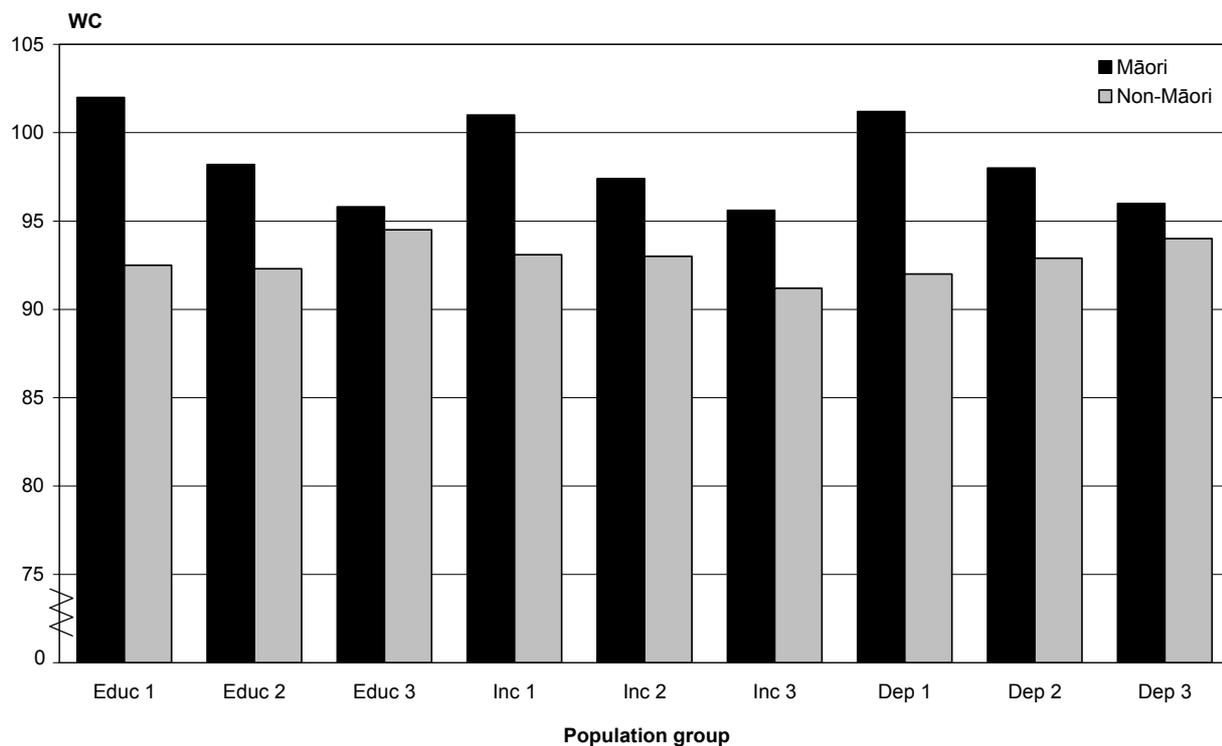
Females



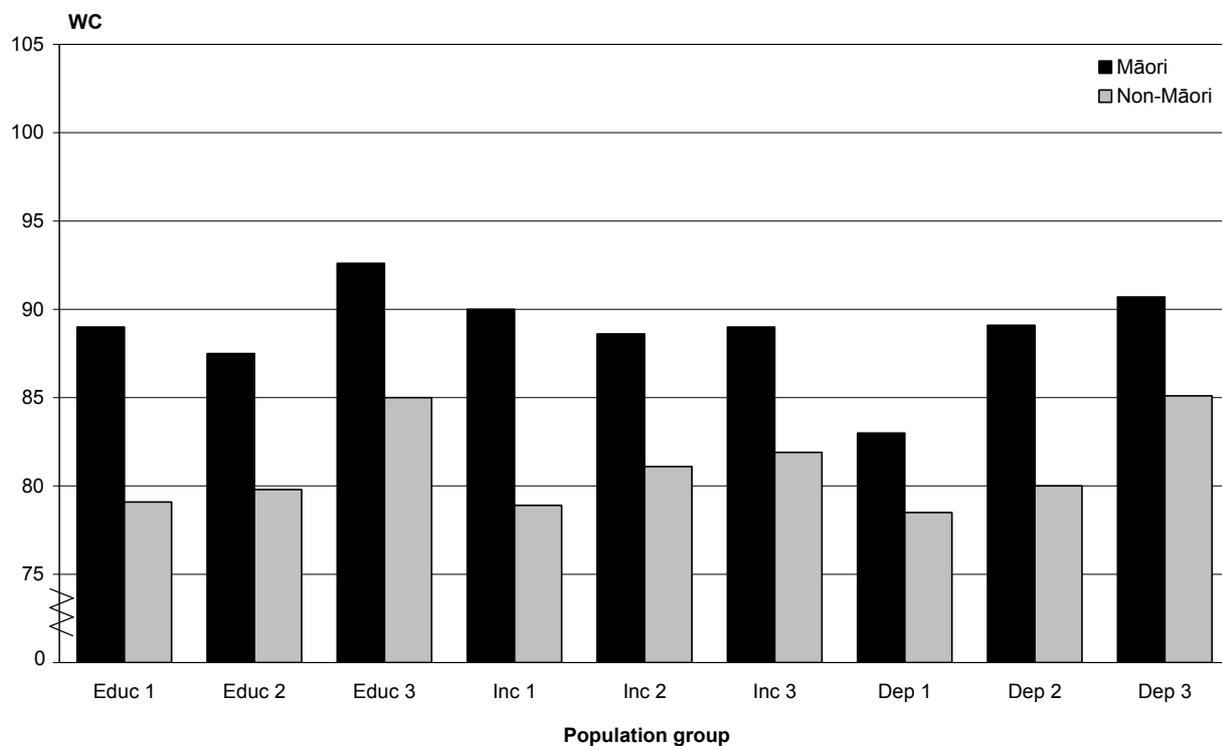
Note: Rates are age standardised within the range 15–74 years. For definitions of socioeconomic categories, see Table 1 (page 3).

Figure 1b: Median of WC distributions, by socioeconomic category, gender and ethnicity, New Zealand, 2002/03

Males



Females



Note: Rates are age standardised within the range 15–74 years. For definitions of socioeconomic categories, see Table 1 (page 3).

Table 2 and Figure 1 show intriguing patterns, perhaps most easily summarised by reference to the medians (50th percentiles) of the BMI and WC distributions. Confidence intervals have been omitted for clarity.

Māori males exhibit a direct relationship between body fat (however measured) and SEP (however measured). That is, higher SEP Māori males tend to be heavier and of wider girth than their less advantaged counterparts.

Māori females, by contrast, show an inverse relationship – but only between WC and small area deprivation. For all other WC–SEP relationships, and all BMI–SEP relationships, the gradient is flat or irregular.

Non-Māori males show a similar pattern to Māori females of shallow and irregular gradients, with the clearest relationship – a shallow inverse gradient – being seen for the WC – small area deprivation relationship.

It is only non-Māori females that are found to exhibit a pattern of strong inverse gradients (for both body fat measures and all three SEP measures). That is, it is only for this population group that lower SEP is clearly associated with a progressively heavier body weight and wider abdominal girth.

Figure 1 shows these patterns only for one point on the BMI or WC distribution – the median. Inspection of Table 2 shows that similar patterns seem to hold right across the distributions, and indeed are more strongly expressed at higher percentiles (such as the 75th and 90th). However, it is difficult to visualise the gradients from a table. While charts equivalent to Figure 1 could be constructed for other percentiles, this difficulty is not removed by doing so.

Multivariable regression modelling might be an alternative (with polytomous modelling for the multiple outcome variables), but given the small number of independent variables (age, sex, ethnicity and socioeconomic position) a stratified analysis is preferred in view of its ease of interpretation.

Tukey M–D plots provide a graphical technique that allows representation of differences between groups across the full BMI or WC distributions in the context of a stratified analysis, and it is to this method that we now turn. Readers unfamiliar with this graphical technique should consult the appendix, which provides a clear explanation of how these plots are constructed (which is very straightforward) and how to interpret them.

Tukey mean–difference analysis

Education

Tukey M–D plots by education are shown for Māori (Figures 2 and 3) and non-Māori (Figures 4 and 5). In all cases, high educational status (university qualification – Educ 1) is the reference or benchmark category. The plots are standardised for age and stratified for gender.

Māori females

Māori females show no significant relationship between education and BMI or WC. With BMI in particular there is a suggestion of a possible inverse gradient (comparing high and low education categories), but no significant differences are observed.

Māori males

Māori males show a *direct* gradient with educational status. Statistically significant differences (or almost significant differences) are observed (at most percentiles) comparing the least educated group (Educ 3 – no qualifications) to the most educated group (Educ 1) for BMI distribution; differences in WC distribution are not statistically significant at any percentile, although the pattern still suggests a direct gradient.

Non-Māori females

For non-Māori females an inverse gradient with education is observed for both BMI and WC. However, statistically significant differences only emerge when comparing Educ 3 (no qualifications) to Educ 1 (tertiary qualification).

The pattern is very similar for both BMI and WC, with the strengths of the associations being approximately equivalent at all points on the respective distributions.

Non-Māori males

For males, the pattern is similar to females, but the differences are smaller and only significant from the 60th percentile of WC and 70th percentile of BMI (whereas female differences are significant from the 30th percentile for both markers).

For both genders, the magnitude of the differences becomes progressively larger with increasing BMI or WC percentile.

Note: For a definition of the education categories, see Table 1 (page 3).

Note: All M–D plots show 95% confidence intervals as error bars around the point estimates. The difference is statistically significant if the error bar does not include $y = 0$ as shown on the chart.

Figure 2: Distributional differences in BMI, by educational status, Māori, 2003

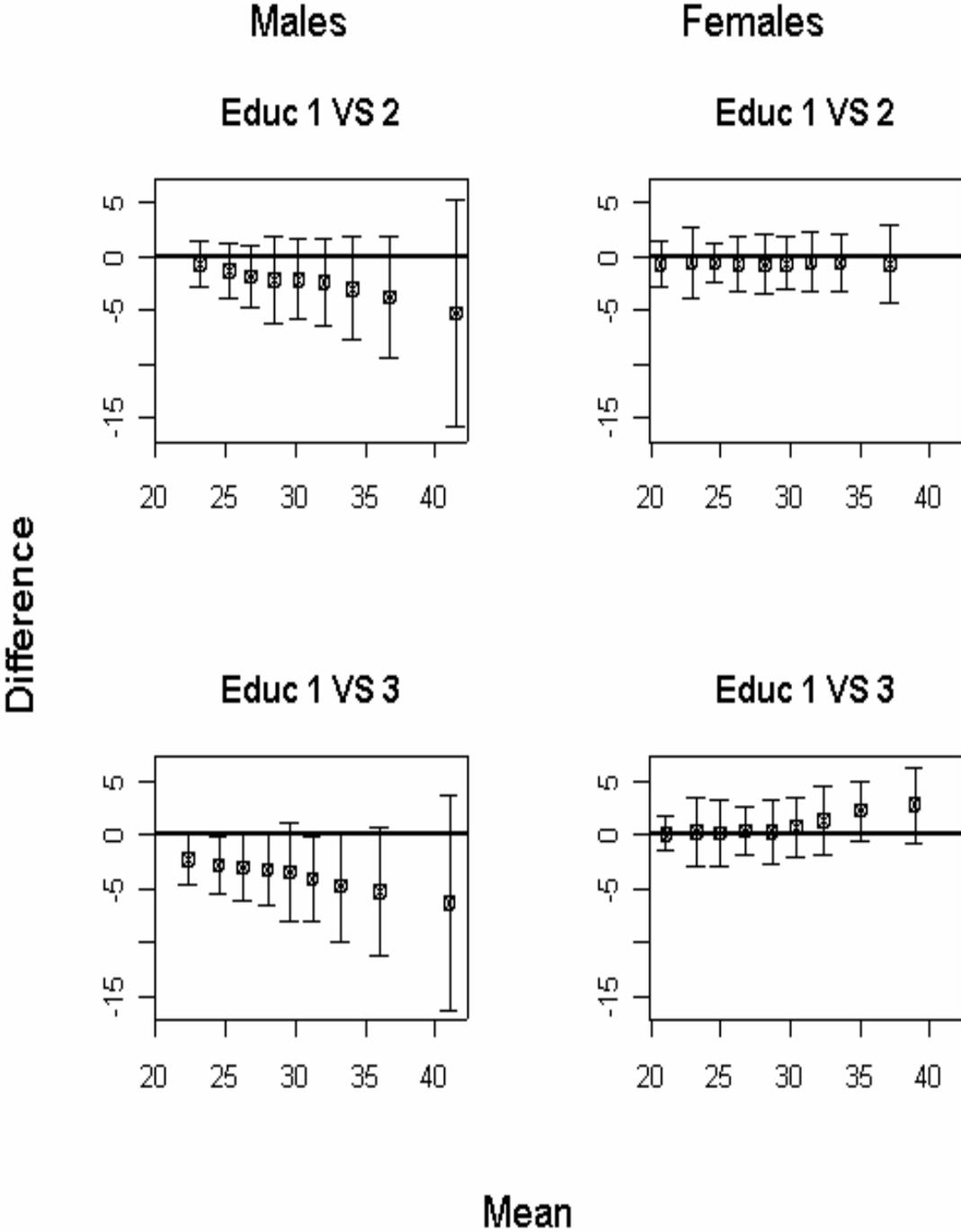


Figure 3: Distributional differences in WC, by educational status, Māori, 2003

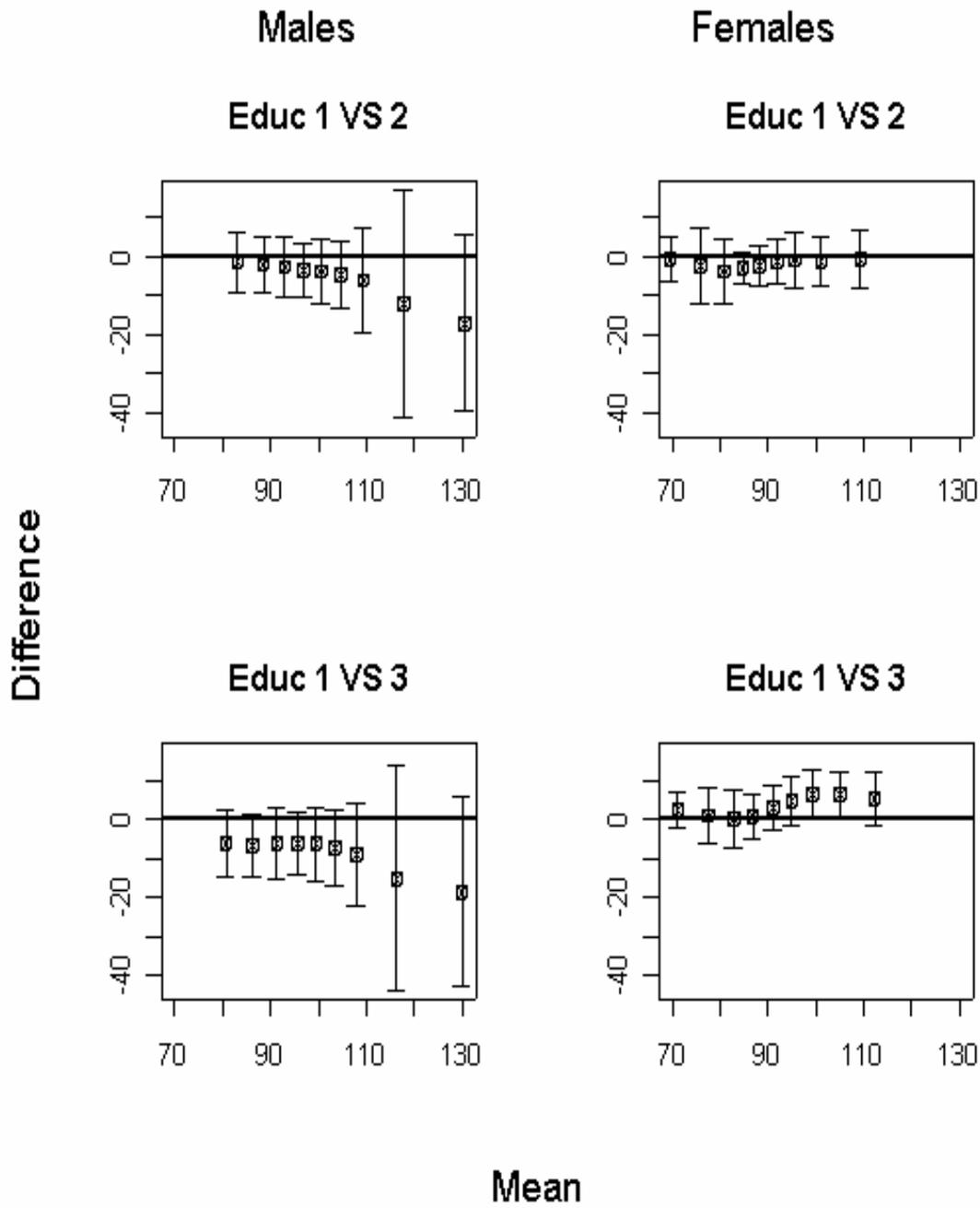


Figure 4: Distributional differences in BMI, by educational status, non-Māori, 2003

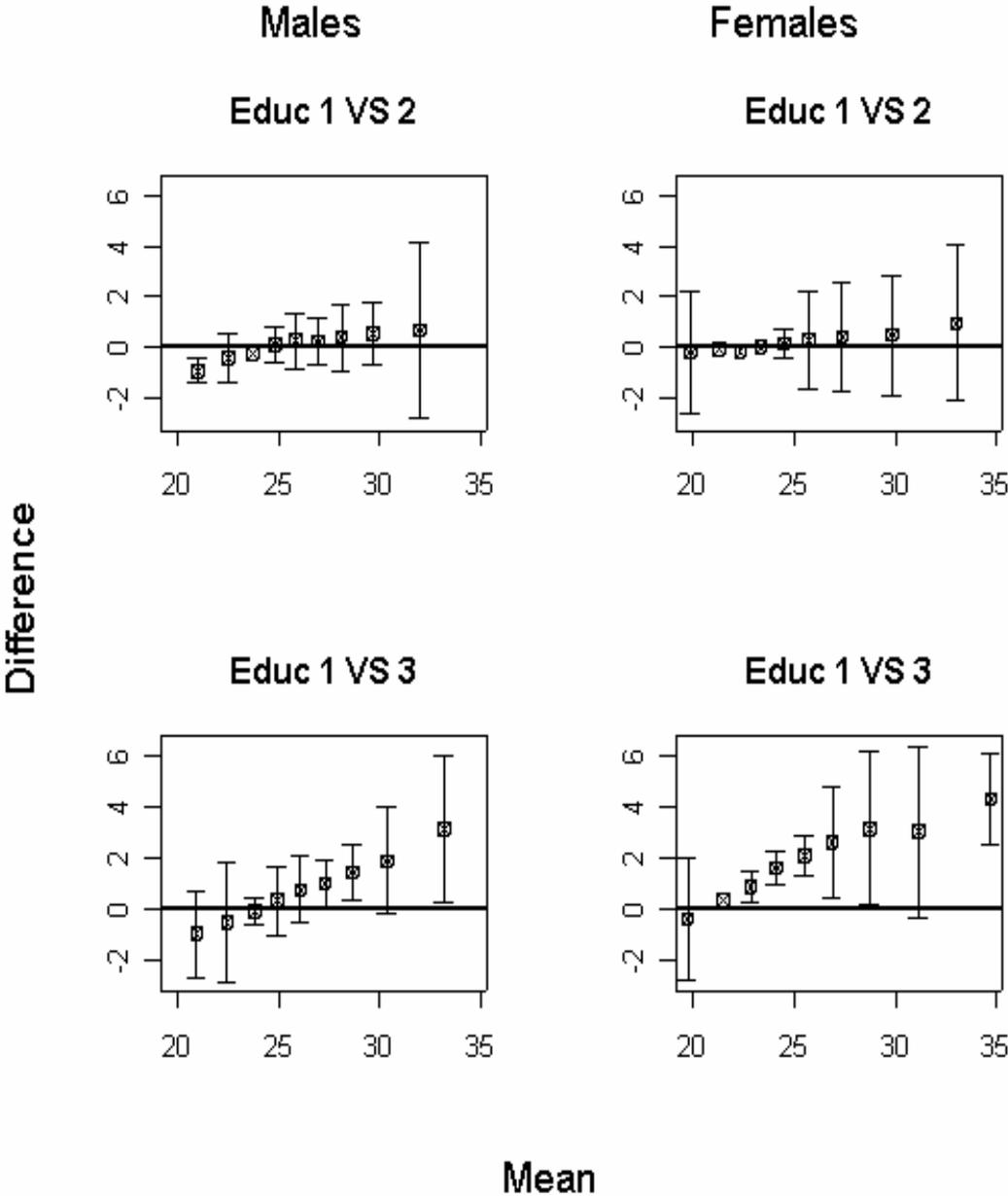
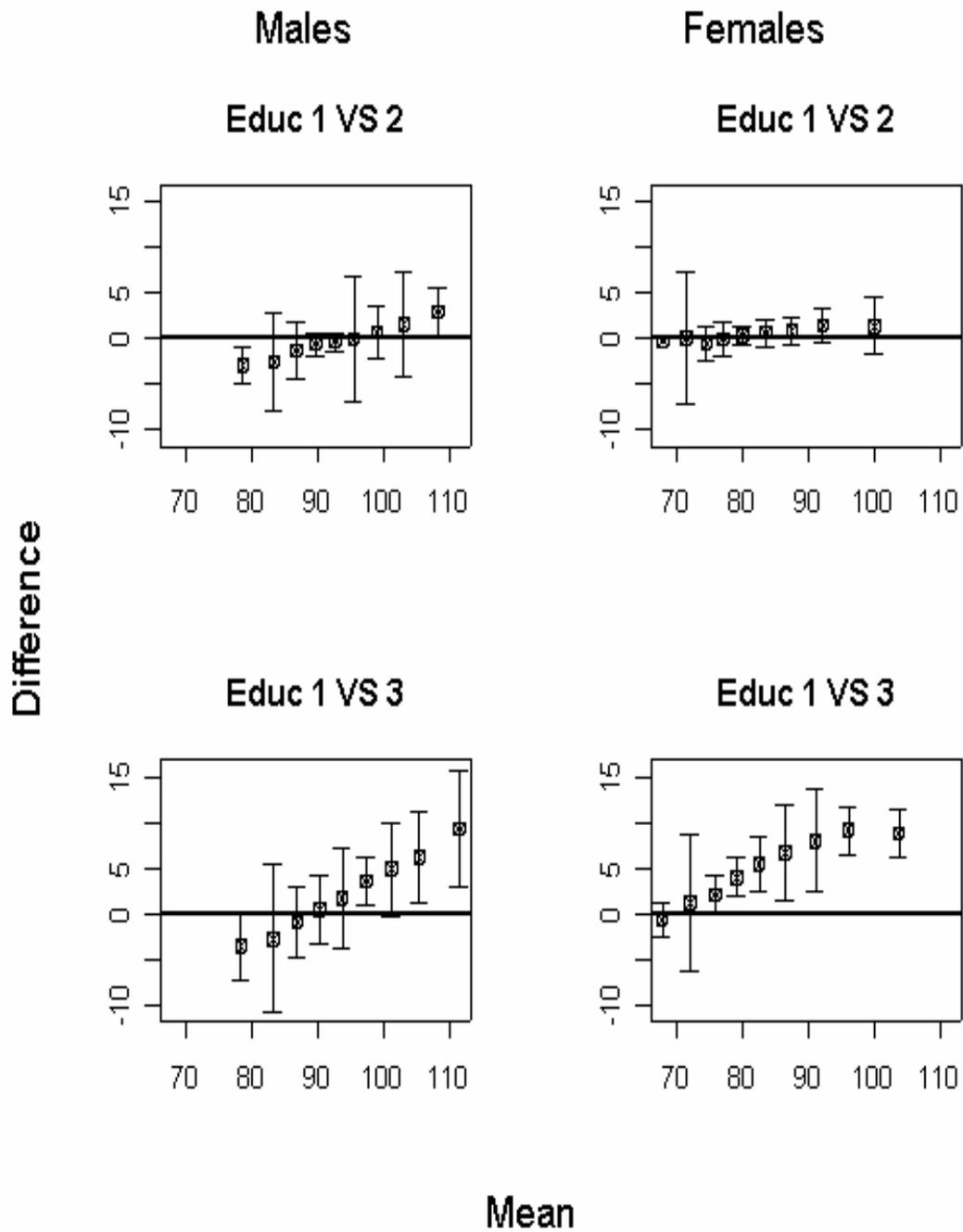


Figure 5: Distributional differences in WC, by educational status, non-Māori, 2003



Household income

Tukey M–D plots by household income are shown for Māori (Figures 6 and 7) and non-Māori (Figures 8 and 9). In all cases, high income (>\$70,000) is the reference or benchmark category. The plots are standardised for age and stratified for gender.

Māori females

Māori females show a weak to no relationship between income and BMI or WC. The only significant difference is observed at the 90th percentile of the WC distribution (comparing high to low income, Figure 7).

Māori males

A *direct* slope is again observed for Māori males (for both BMI and WC). For both markers, significant differences emerge at several percentiles when comparing the high- to the low-income group, but only at the 90th percentile when comparing the high- with the middle-income group. The magnitude of the differences is particularly striking for WC: the 90th percentile of WC distribution for medium and low-income Māori males is almost 20 cm *less* than that of their high-income counterparts.

Also, for Māori males there is no stepped gradient for WC: Māori males from medium- and low-income households are equally favoured (in terms of the absolute difference in percentiles) when compared to high-income males.

Non-Māori females

Non-Māori females show a strong inverse gradient with income. Comparing the high-income group to the medium-income group, non-Māori females show significant or near-significant differences from about the 40th percentile for BMI (Figure 8) and the 30th for WC (Figure 9). Comparing high and low income groups, significant differences begin to emerge at the 10th and again the 30th percentiles respectively.

Again, the differences in percentiles are directly proportional to BMI and WC, indicating that the largest inequalities exist in the morbidly obese population. Overall, the strength and pattern of the association (between SEP and body fat) in this population group is similar whichever marker of adipose tissue mass (BMI or WC) and socioeconomic position (education or income) is used (as can be seen by comparing Figures 4, 5, 8 and 9).

Non-Māori males

Non-Māori males show only a possible weak inverse relationship between income and both BMI and WC, only visible (at restricted percentiles) when comparing the high- to the low-income group. For non-Māori males (unlike females), the association between SEP and BMI or WC is more evident for education than for income (although even then the slope of the gradient is much shallower than that among females).

Note: For a definition of the income categories, see Table 1 (page 3).

Figure 6: Distributional differences in BMI, by income, Māori, 2003

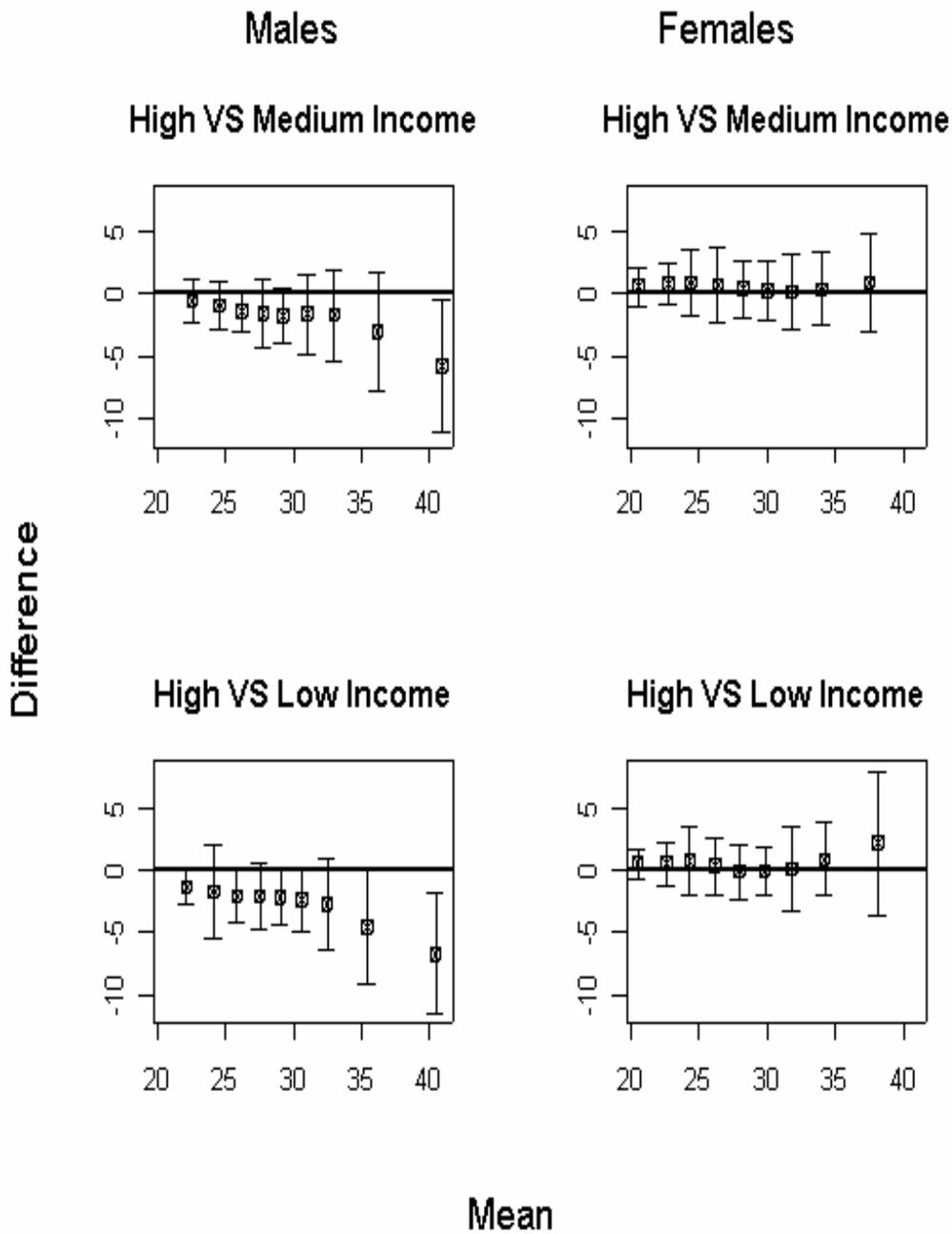


Figure 7: Distributional differences in WC, by income, Māori, 2003

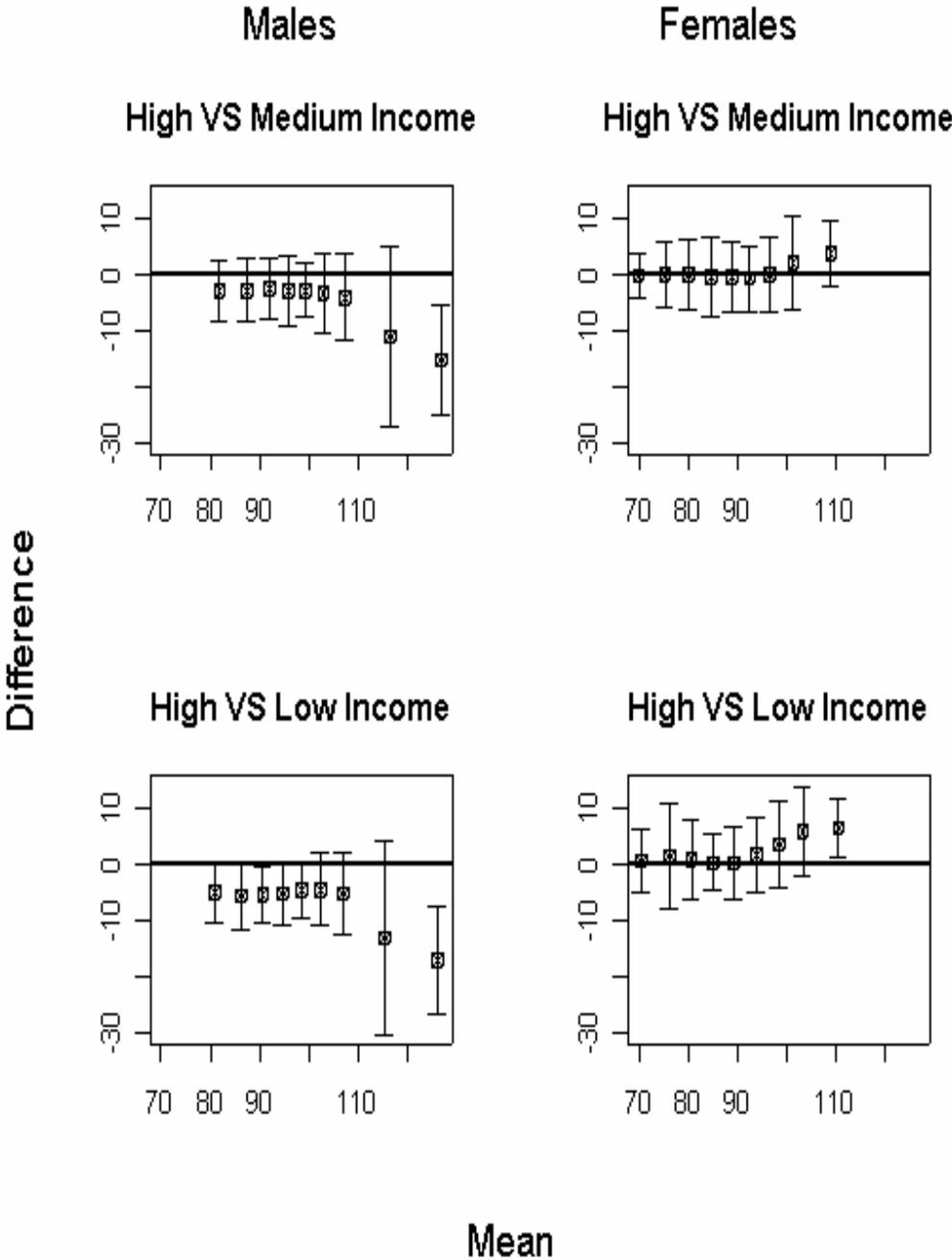


Figure 8: Distributional differences in BMI, by income, non-Māori, 2003

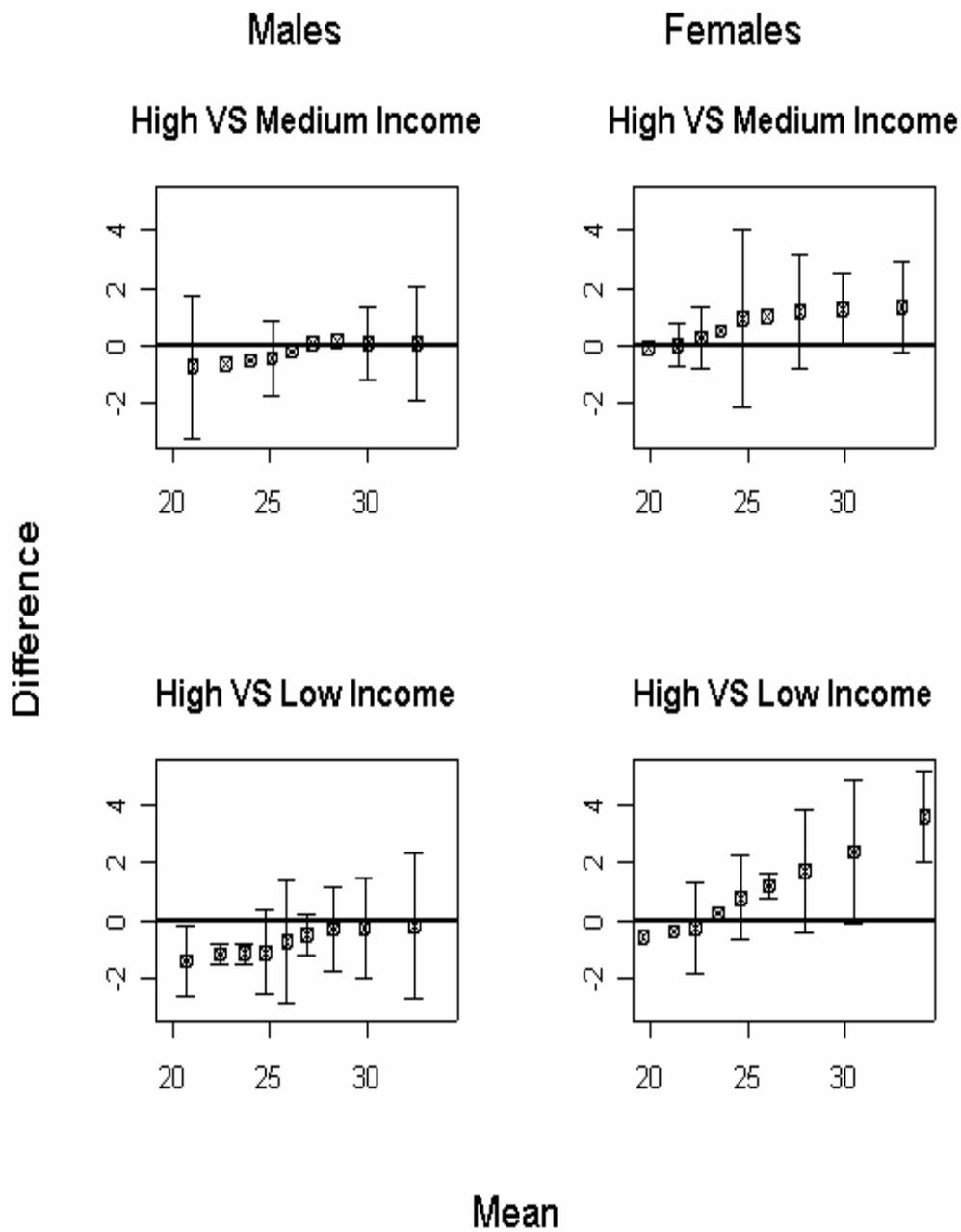
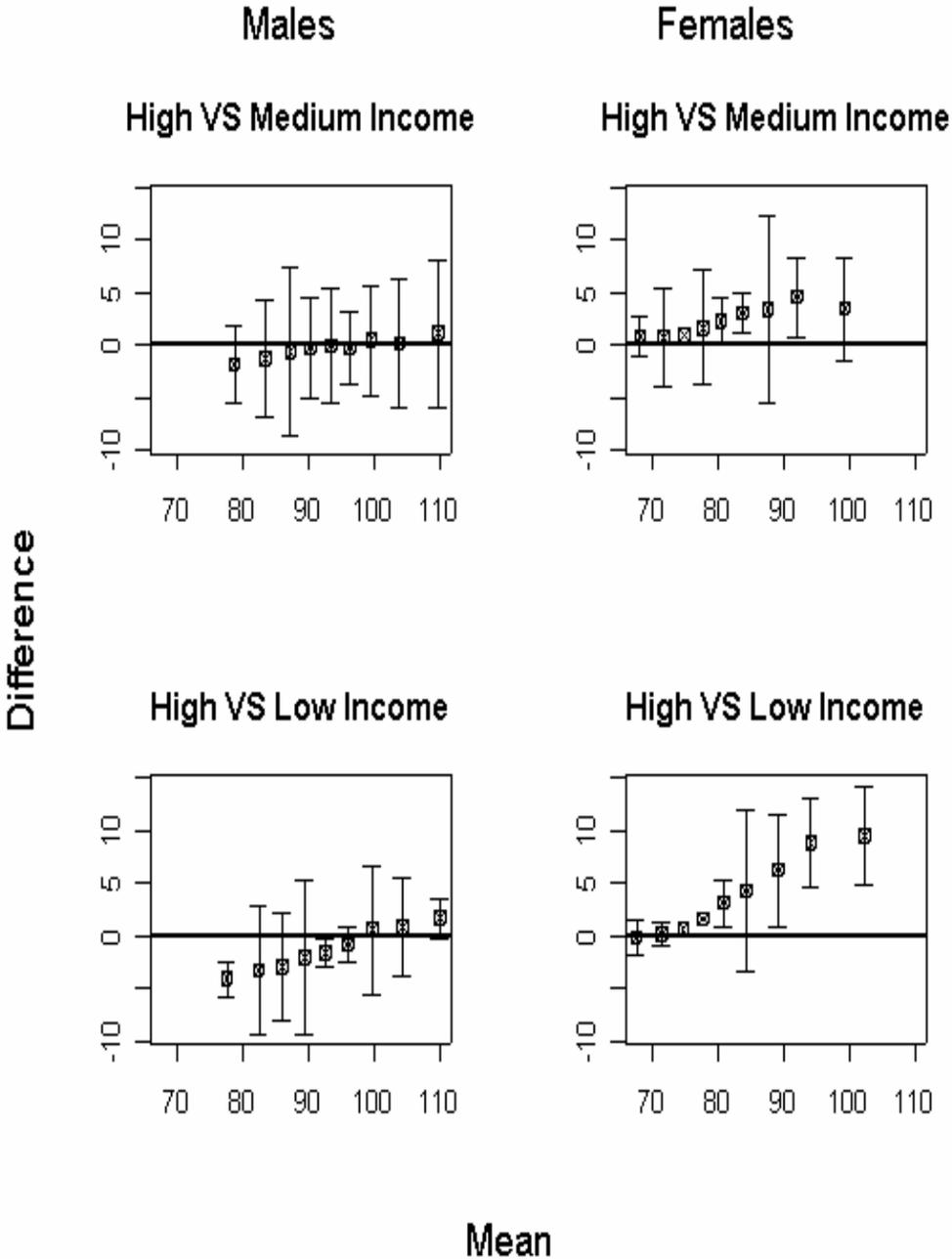


Figure 9: Distributional differences in WC, by income, non-Māori, 2003



Deprivation (NZDep2001)

Tukey M–D plots by deprivation category of neighbourhood (aggregated NZDep2001 quintiles) are shown for Māori (Figures 10 and 11) and non-Māori (Figures 12 and 13). In all cases, low deprivation (NZDep2001 quintiles 1 and 2) is the reference or benchmark category. The plots are standardised for age and stratified for gender.

Māori females

Among Māori females, significant differences are observed for both BMI and WC distributions when comparing Dep Cat 1 to both Dep Cats 2 or 3. When comparing Dep Cat 1 to 2 for BMI distribution (see Figure 10), a uniform shift of 2.5 BMI units is observed across all percentiles (with significant differences observed at all percentiles except the 70th and 80th). Comparing the distributional differences in BMI between Dep Cat 1 and 3, significant differences are observed across all percentiles, but the differences increase with increasing BMI percentile.

A uniform shift of approximately 8 cm across all percentiles is observed when comparing Dep Cat 1 to 2 for Māori female WC distribution. Significant differences occur at all but the 10th and 60th percentiles. The trend is similar when comparing Dep Cat 1 to 3. A uniform shift of around 8 cm is again observed across all percentiles – although the differences at the 80th and 90th percentiles are marginally higher. Statistically significant differences are observed at all percentiles.

Deprivation is thus the only SEP measure for which a clear (if weak) relationship is seen with BMI or WC in this population group.

Māori males

For Māori males, although visually the *direct* slope re-occurs between BMI or WC and neighbourhood deprivation (similar to that seen for education and income), no significant differences are observed at any percentile for either BMI or WC.

Non-Māori females

Among non-Māori females, no significant differences are seen when comparing BMI distributions of Dep Cat 1 (low neighbourhood deprivation) to Dep Cat 2 (medium neighbourhood deprivation) (see Figure 12). The same is true for WC distribution, except for a small (but statistically significant) difference of 2.5 cm at the 70th percentile (see Figure 13).

When comparing Dep Cat 1 to Dep Cat 3 (high neighbourhood deprivation), however, significant differences emerge. Statistically significant inverse differences are observed at the 40th to 90th percentiles for both BMI and WC distributions.

Also, judging from the point estimates alone, the absolute differences in percentiles are directly related to BMI or WC – indicating that the most substantive distributional changes occur at the largest percentiles.

The neighbourhood deprivation pattern thus mirrors the findings using household and individual measures of SEP among non-Māori females. The strength of association is about the same for all markers of SEP and for both markers of body fat.

Non-Māori males

The pattern for non-Māori males is very similar to that for non-Māori females, but the slope of the socioeconomic gradient in BMI or WC is much shallower. Although the overall visual impression suggests an inverse gradient of BMI and WC with deprivation category, in fact for non-Māori males significant differences are only observed between the 60th and 90th percentiles of the BMI distribution and the 70th and 80th percentiles of the WC distribution, comparing extreme categories.

The magnitude of the differences is about the same whether BMI or WC is used as the measure of (excess) body fat mass. The association between BMI or WC and SEP also appears about equally strong whether measured using deprivation or education, but greater than when using income as the SEP indicator.

Note: For a definition of the deprivation categories, see Table 1 (page 3).

Figure 10: Distributional differences in BMI, by NZDep category, Māori, 2003

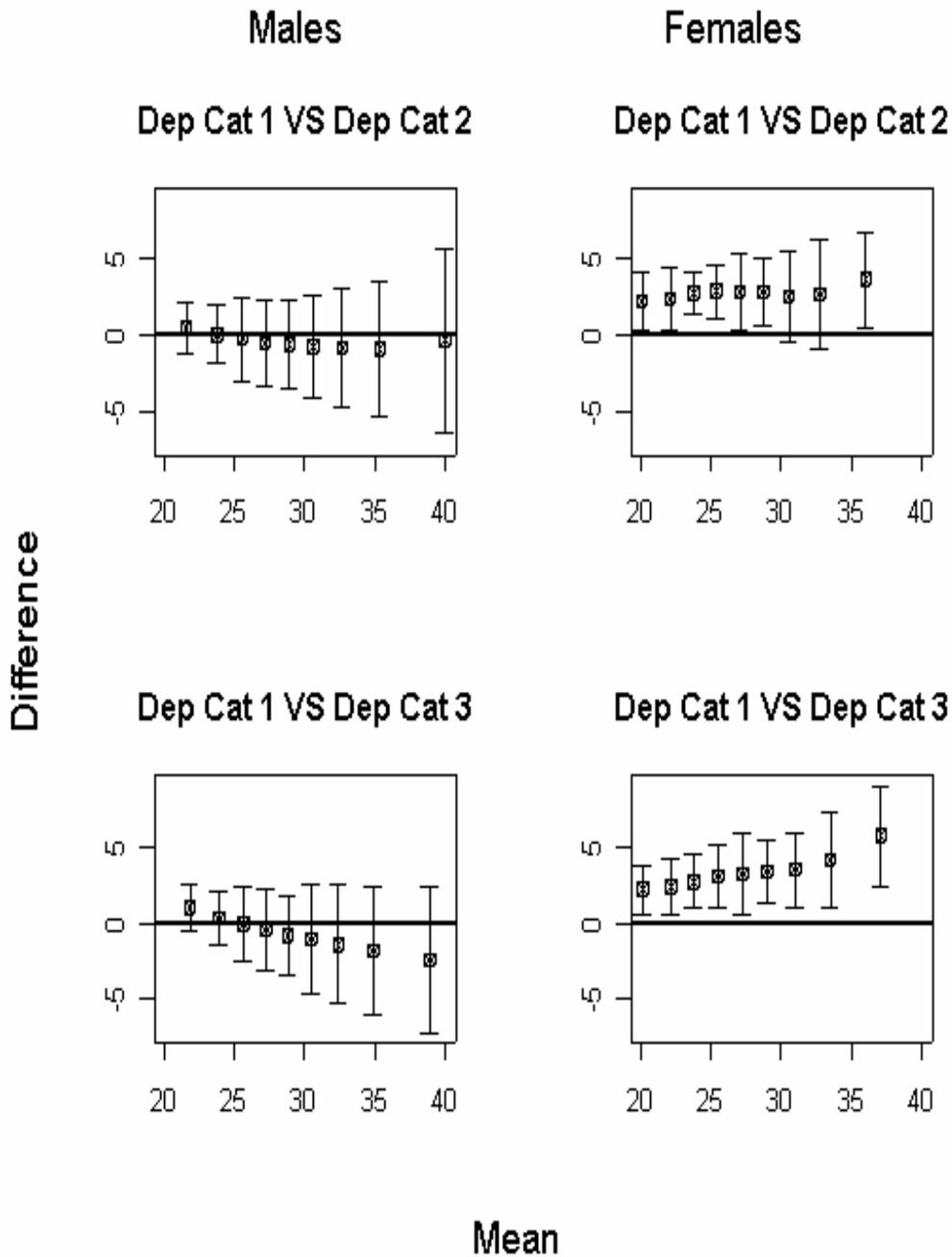


Figure 11: Distributional differences in WC, by NZDep category, Māori, 2003

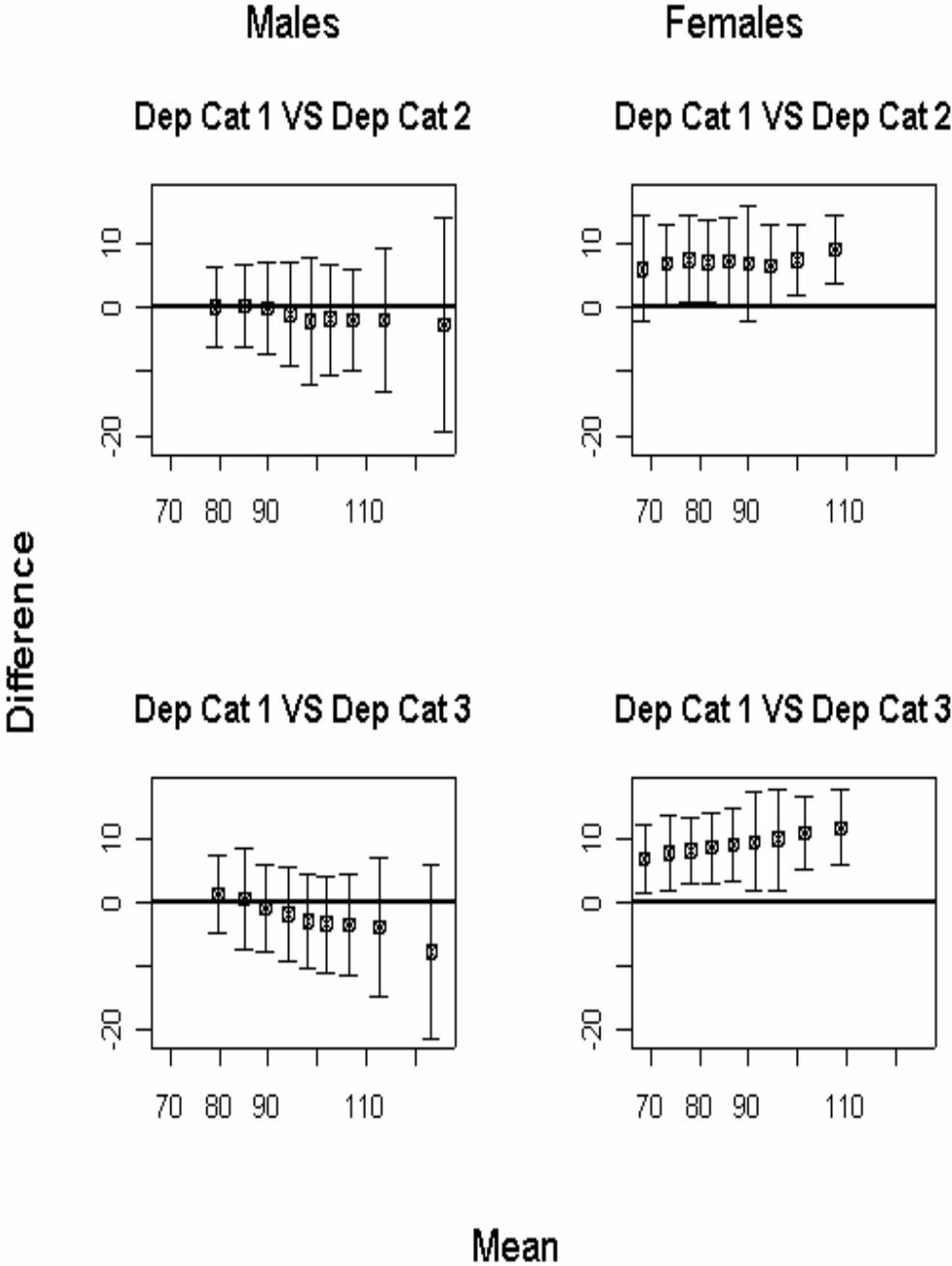


Figure 12: Distributional differences in BMI, by NZDep category, non-Māori, 2003

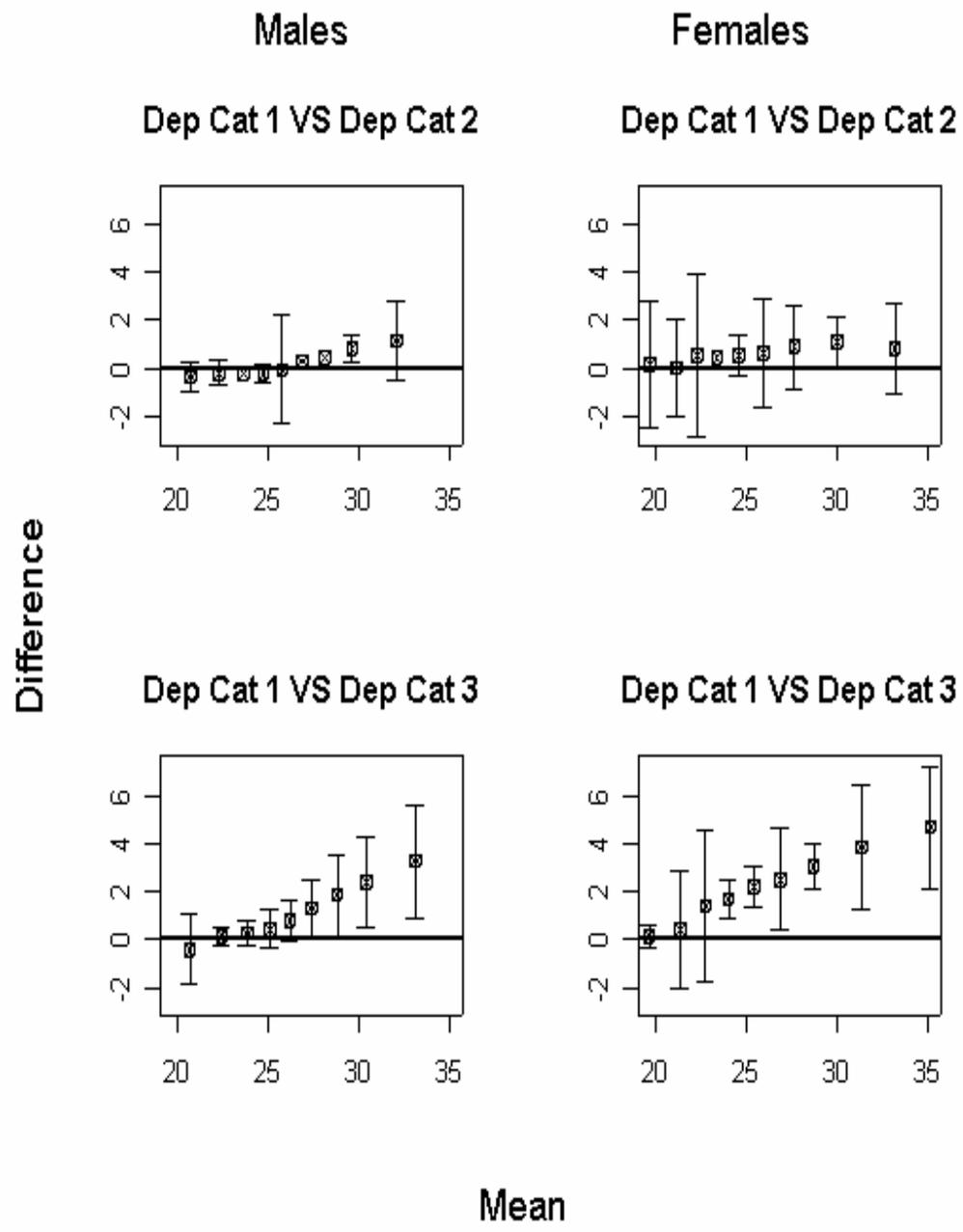
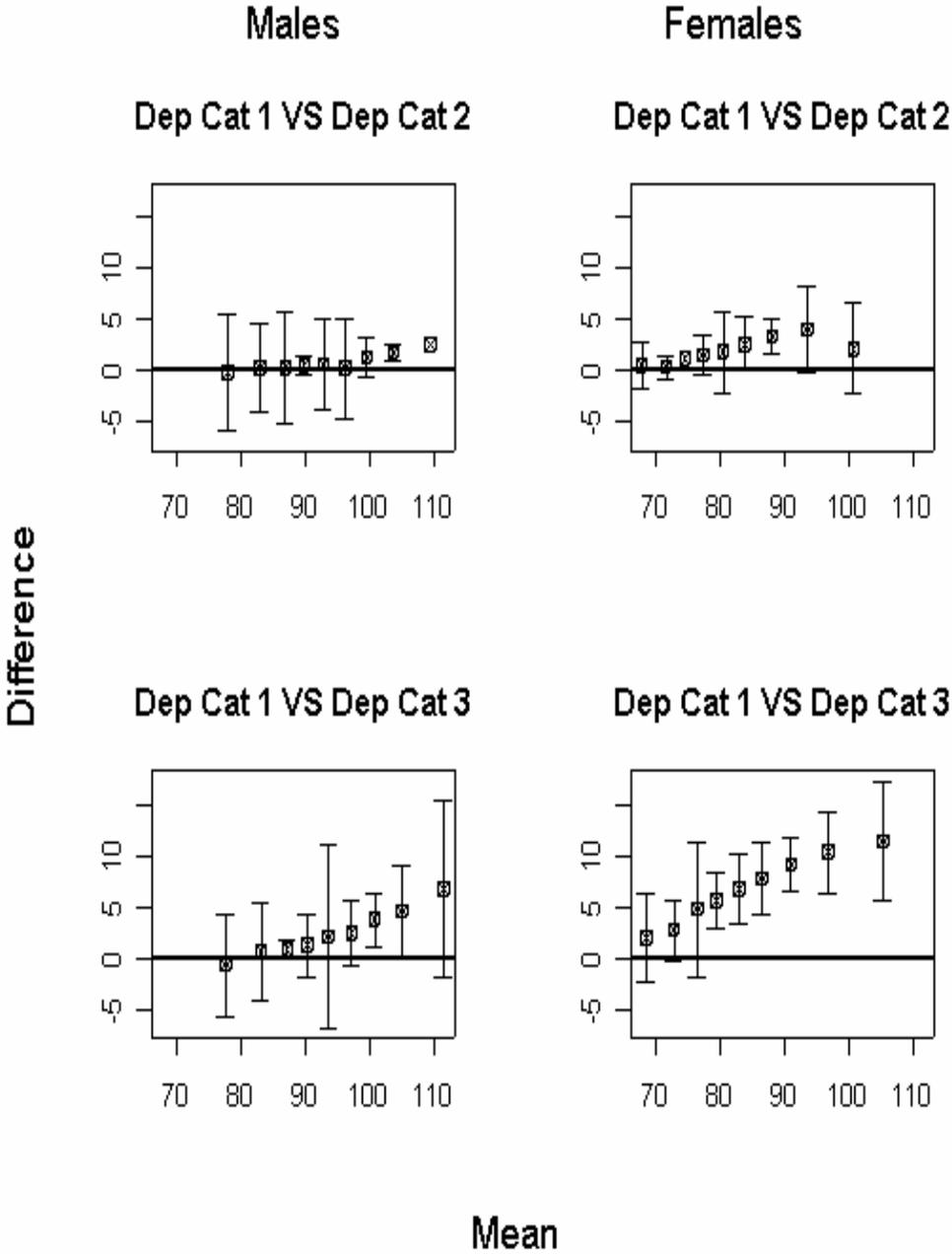


Figure 13: Distributional differences in WC, by NZDep category, non-Māori, 2003



Discussion

This analysis shows that marked differences exist between population subgroups in New Zealand in the strength and direction of the SEP–BMI and SEP–WC relationships. For non-Māori females, BMI and WC distributions are (significantly) inversely related to all three markers of SEP. For non-Māori males, significant distributional differences are again observed for all three SEP markers, but the socioeconomic gradient is shallow (especially for income) compared to that for non-Māori females.

Māori females, on the other hand, show no relationship between BMI or WC and education, and a weak inverse relationship with household income (the only significant difference being observed at the 90th percentile of both BMI and WC distributions). A weak uniform shift across all percentiles is observed when small area deprivation is used as the marker of SEP for this demographic subgroup.

Perhaps the most interesting results are those for Māori males. The direction of the relationship between SEP and BMI or WC is counterintuitive – with elevated BMI and WC being associated with *higher* household income and education (no significant associations were noted with NZDep2001 categories, although the same [ie, direct] relationship is visible if only the point estimates are considered).

These findings indicate that the effect of SEP on BMI or WC varies with SEP marker, but is generally in the same direction whether SEP is measured at the individual, household or neighbourhood level. Also, the relationship is similar in direction and magnitude whether BMI or WC is used as the marker of body fat. This is counterintuitive, since low SEP is associated with chronic stress affecting cortisol levels, which in turn would be expected to promote abdominal fat deposition and so elevate WC more than BMI (Marmot 2005). However, in our data set SE gradients were equally steep for WC and BMI.

More importantly, we found that the effect of SEP at any level on BMI or WC is modified by both gender and ethnicity. What might explain these marked gender and ethnic differences in the socioeconomic gradients in BMI and WC?

Several studies have related gender differences in the gradient to behavioural differences, life-course effects, and timing of the epidemic (Aranceta et al 2001; Ball et al 2003). Behavioural differences may involve both diet/nutrition and physical activity. For example, working-class men may be partly protected against adult weight gain by physically demanding manual jobs – a protection not afforded their female counterparts.

Alternatively, males and females may be subject to different social pressures regarding desirable body weight (Paeratakul et al 2002). If females experience greater social pressure than males, and if higher ranked females in particular perceive greater social desirability in being slim than their less-advantaged counterparts, or are better able to respond to such social pressures, then stronger inverse gradients would be generated for females than males (Laitinen et al 2001).

In terms of life-course effects, there is evidence that obesity among males is more strongly determined by their childhood SEP than their adult SEP, yet this is much less so for females (Langenberg et al 2003; Ball and Mishra 2006). Given some degree of

social mobility, this would result in steeper gradients for females than males in relation to *adult* SEP.

In terms of differential timing of the obesity epidemic between the genders, there is evidence that the epidemic began earliest and is most advanced in females, at least in New Zealand (Ministry of Health 2004c). If this is associated with an 'obesity transition', in which more advantaged groups are better able to regain control of their body weight than their less advantaged counterparts, then an inverse gradient will emerge earlier among females.

Other studies have examined ethnic differences, relating these to cultural perceptions of body image and preferred body shape (Paeratakul et al 2002; Pollock 2001; Craig et al 1996). In some cultures, traditional values may persist with respect to large body size being preferred (or at least less stigmatised) for men than for women. For example, a study comparing Cook Islanders' with Australians' perceptions of body size found that Cook Island participants chose larger ideal sizes than did the Australian participants, for both males and females. However, this study also found that traditional preferences for large body size were changing towards the Western ideal of a slim body for women, but not for men (Craig et al 1996). Similar results have been found in other studies in the Pacific islands (Swinburn et al 2004), and in one study of ethnic differences in perception of body size among Pacific, Māori and European New Zealanders (Metcalf et al 2000).

Whatever the explanations, our results may be useful for policy in terms of what they reveal about gender, ethnic and socioeconomic inequalities in excess body fat at the present time. Especially noteworthy is the perhaps unanticipated *direct* socioeconomic gradient seen among Māori males. The finding that these gender and ethnic variations in the socioeconomic gradients in body fat are largely consistent across markers of outcome (BMI and WC) and exposure (individual education, household income, neighbourhood deprivation) further reinforces the need to take these patterns into account when designing interventions (Buskirk 1998). Failure to do so risks counterproductive interventions that could potentially further increase existing ethnic, gender and socioeconomic inequalities in population body fat distribution. In conclusion, our analysis has revealed intriguing patterns of socioeconomic, ethnic and gender inequalities in population BMI and WC distributions in New Zealand in 2002/03. These patterns will need to be monitored and can be expected to evolve further over time. Qualitative research into cultural perceptions of body image may be a useful accompaniment to such monitoring.

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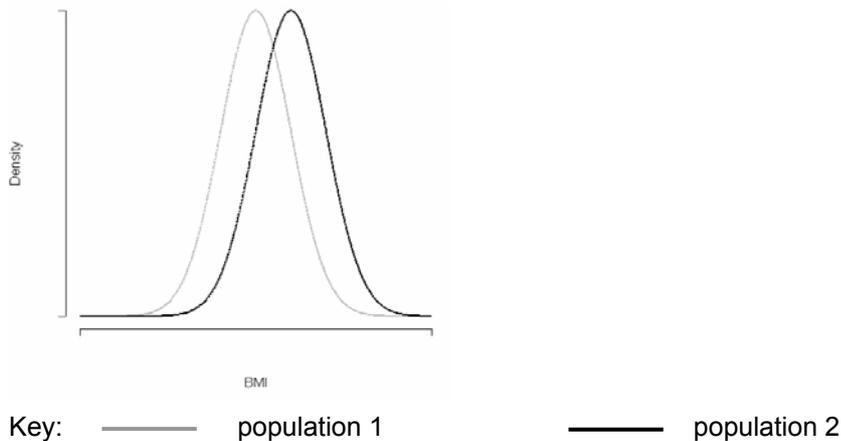
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Appendix: Describing BMI or WC Distributions

Although this report focuses on Tukey mean–difference plots, we consider here all the different ways in which two distributions may be compared in order to provide a context within which the M–D plots can be understood. The two distributions being compared may be BMI or WC distributions (or any other variable); and may refer to two different populations at one point in time, or the same population at two different points in time.

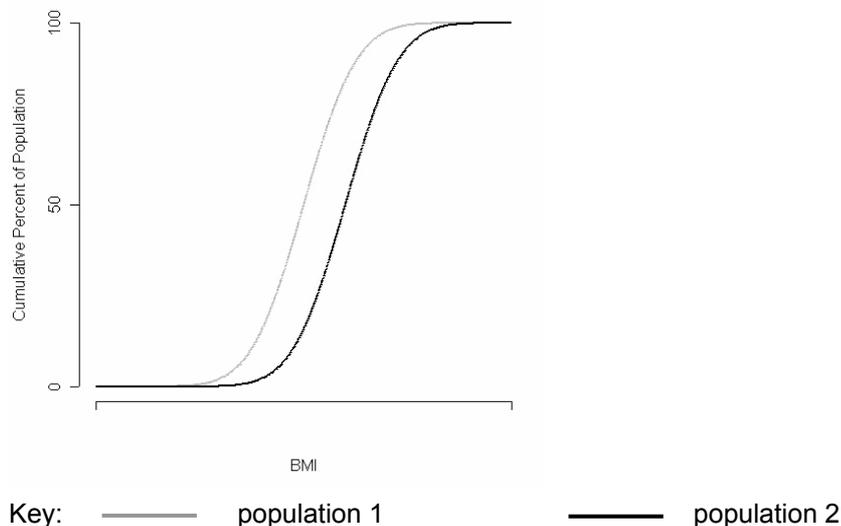
The simplest way to examine differences between two BMI distributions (for example) is simply to show both distributions as relative frequency histograms in the same chart (a relative frequency histogram plots the proportion of the population with each level of BMI against the BMI). Here the histogram is smoothed over the BMI intervals using kernel smoothing in order to visualise the whole distribution more clearly. This process gives kernel densities (Figure A1).

Figure A1: BMI distribution (kernel densities)



Another graphical method often used to compare two distributions is the cumulative distribution. The cumulative distribution shows, for each of the populations, the cumulative percent of the population at each BMI value (Figure A2).

Figure A2: Cumulative BMI distribution

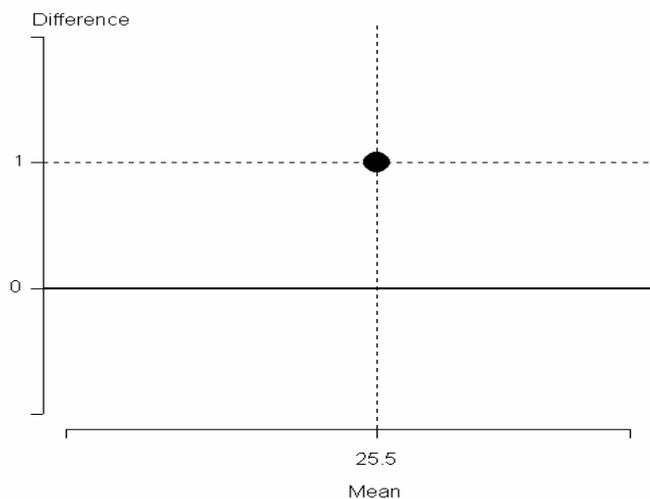


It is easier to visualise the difference between the two distributions using the cumulative distribution than the simple relative frequency histogram (kernel densities), but it is still difficult to see changes at the extremes of the distributions, and to quantify the distributional shift.

A method that overcomes both of these limitations is the Tukey mean–difference (m–d) plot (Cleveland 1993).

The m–d plots show the difference between the two distributions at each percentile against the mean of the two percentiles. For example, if the BMI value of the 50th percentile was 26.0 for one distribution and 25.0 for the other, then the m–d plot would show an x-axis value of 25.5 and a y-axis value of 1.0 (and so on for all other percentiles) (Figure A3).

Figure A3: Tukey mean–difference plot (single percentile only shown)



Note that if no shift had occurred at this percentile, the y-axis value would have been zero (and the x-axis value would have remained 25.5). So no shift at any percentile (identical distributions) is represented in an m–d plot as a horizontal line at zero.

A uniform shift or difference would produce a horizontal line whose distance from zero indicates the size of the (uniform) difference between the two BMI distributions (Figure A4).

If the difference between the two distributions increases with increasing BMI (ie, is greater among the obese than the merely overweight), this will be represented by a sloped line, rising progressively away from the horizontal zero line at higher BMI percentiles (Figure A5).

Figure A4: Uniform difference between two distributions: kernel density plot (top), cumulative distribution plot (middle), and Tukey mean–difference plot (bottom)

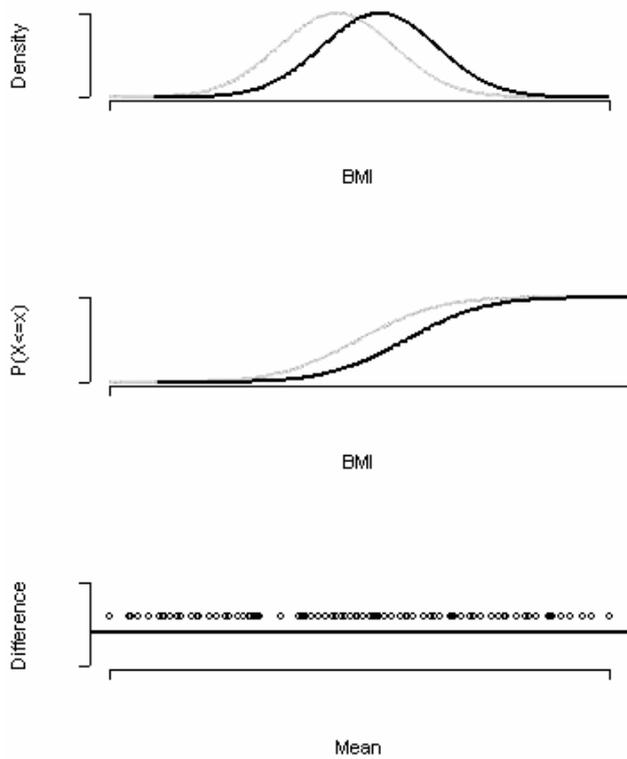


Figure A5: Increasing difference between two distributions: kernel density plot (top), cumulative distribution plot (middle), and Tukey mean–difference plot (bottom)

